# Outcomes of Patients With Acute Type B (DeBakey III) Aortic Dissection
## A 13-Year, Single-Center Experience

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***Background***—Aortic dissection remains the most common aortic catastrophe. In the endovascular era, the management of acute type B aortic dissection (ATBAD) is undergoing dramatic changes. The aim of this study is to evaluate the long-term outcomes of patients with ATBAD who were treated at our center over a 13-year period.

***Methods and Results***—We reviewed patients with ATBAD between 2001 and 2014, analyzing variables based on status (complicated [c] versus uncomplicated [u]) and treatment modalities. We defined cATBAD as rupture, expansion of diameter on imaging during the admission, persistent pain, or clinical malperfusion leading to a deficit in cerebral, spinal, visceral, renal, or peripheral vascular territories at presentation or during initial hospitalization. Postoperative outcomes were defined as deficits not present before the intervention. Outcomes were compared between the groups by use of Kaplan-Meier and descriptive statistics. We treated 442 patients with ATBAD. Of those 442, 60.6% had uATBAD and were treated medically, and 39.4% had cATBAD, of whom 39.0% were treated medically to 30.0% with open repair, 21.3% with thoracic endovascular aortic repair, and 9.7% with other open peripheral procedures. Intervention-free survival at 1 and 5 years was 84.8% and 62.7% for uATBAD, 61.8% and 44.0% for cATBAD-medical, 69.2% and 47.2% for cATBAD-open, and 68.0% and 42.5% for cATBAD–thoracic endovascular aortic repair, respectively (*P*=0.001). Overall survival was significantly related primarily to complicated presentation.

***Conclusions***—In our experience, early and late outcomes of ATBAD were dependent on the presence of complications, with cATBAD faring worse. Although uATBAD was associated with favorable early survival, late complications still occurred, mandating radiographic surveillance and open or endovascular interventions. Prospective trials are required to better determine the optimal therapy for uATBAD. (***Circulation***. 2015;132:748-754. DOI: 10.1161/ CIRCULATIONAHA.115.015302.)

**Key Words:** aorta ■ dissection ■ endovascular procedures ■ surgery

Currently, acute aortic dissection remains the most common aortic catastrophe,[1–3] with management and prognosis determined by location of the affected aortic segment. Acute aortic dissection involving the ascending aorta, Stanford type A or DeBakey type I or II, is treated with urgent surgical intervention, whereas acute aortic dissection involving the descending thoracic aorta or thoracoabdominal aorta (Stanford type B or DeBakey type III) is managed medically or by surgical or endovascular intervention when complicated.[4]

Over the past decade in the United States, the management of acute type B aortic dissection (ATBAD) has evolved from primary initial medical management to endovascular intervention, especially for complicated presentation.[5] Patients with complicated (c) ATBAD treated with thoracic endovascular

aortic repair (TEVAR) had improved outcomes compared with patients treated with open aortic repair.[6–8] However, the treatment of uncomplicated (u) ATBAD remains controversial. Much controversy has arisen as the result of recent evidence demonstrating beneficial midterm outcomes from endovascular treatment of uATBAD.[9–11] This mounting evidence recently led the US Food and Drug Administration to expand the indications of thoracic endovascular stent grafts to include all disorders of the thoracic aorta, including the treatment of all type B aortic dissections, despite few long-term data on patients with cATBAD and no data on uATBAD.

In 2006, we reported our experience with the management of ATBAD before our adoption of endovascular techniques for aortic dissection.[12] In that report, we primarily managed

ATBAD with medical management unless complications arose. At that time, the majority of complicated dissections that required interventions were undertaken by open surgical treatment. Since that time, our paradigm for the management of ATBAD has evolved. Thus, the purpose of this study was to examine and analyze our experience with ATBAD and to report both early and late outcomes over a 13-year period at our center.

## Methods

Data collection and analysis for this study were approved by the Committee for the Protection of Human Subjects at University of Texas Houston Medical School at Houston and Memorial Hermann Hospital in Houston, TX. The requirement of informed consent was waived. The study was observational, arising from data collected from a single institution. We reviewed medical records of all patients with ATBAD admitted to our center between January 2001 and June 2014. These included direct admissions from the emergency department or direct transfers to the cardiovascular surgery intensive care unit from an outside hospital after the establishment of the diagnosis of ATBAD. Clinical data were collected on baseline patient characteristics, presentation, inpatient management, and follow-up. Data were analyzed to evaluate in-hospital complications and long-term outcomes on the basis of status (complicated versus uncomplicated) and treatment modalities.

The treatment modalities included medical, open aortic surgical repair, aortic endovascular repair, and peripheral vascular bypass or intervention. With the diagnosis of ATBAD, patients were designated as either uncomplicated or complicated on the basis of the previously established definitions.[12] Patients who were initially classified as uncomplicated but developed complications at any time during the initial admission were deemed complicated for analysis. cATBAD patients were further classified by treatment modality as medical, open aortic surgical, aortic endovascular, and peripheral vascular. Peripheral vascular included any patient who required a dissection-related vascular procedure (Figure 1).

### Definitions

Aortic dissection was classified as type B, according to the Stanford classification, if the dissection did not involve the ascending aorta.[13] In recent years, with the increasing use of TEVAR, we have referred to the DeBakey classification, as originally described in 1965, specifically DeBakey type IIIa and IIIb, because this designation is more anatomically specific.[14] Only patients who presented in the acute setting were included in the study. Acute was defined as the clinical diagnosis made within 2 weeks of presentation; subacute, between 2 and 6 weeks; and chronic, > 6 weeks after the onset of symptoms.[15]

We defined cATBAD as rupture, expansion of diameter on imaging during the admission, persistent pain, and clinical malperfusion leading to a deficit in cerebral, spinal, visceral, renal, or peripheral vascular territories at presentation or during the initial hospitalization. This was determined on both radiographic and clinical grounds. Patients with isolated penetrating aortic ulcers were excluded. Early mortality was defined as death occurring within 30 days of admission or death occurring during initial hospitalization.[15]

### Clinical Management

On admission, acute aortic dissection protocol was initiated in all patients diagnosed with ATBAD. This included admission to the cardiovascular surgery intensive care unit, continuous arterial blood pressure monitoring, central venous access for antihypertensive medication, and urine output monitoring. The management goal was to achieve a systolic blood pressure between 100 and 120 mm Hg with resolution of symptoms.[4] Patients with cATBAD underwent an intervention based on their type of complication.

Once blood pressure was controlled and treatment was transitioned to oral antihypertensive medications, patients were transferred from the cardiovascular surgery intensive care unit. Before discharge, patients underwent a chest, abdomen, and pelvis computed

tomography study without contrast or magnetic resonance imaging to establish the baseline aortic status and to assess for rapid aortic growth since the initial admission scan.[12]

### Open Aortic Repair

Indications for open surgical intervention included aortic rupture, aortic expansion (diameter >5 cm or rapid increase in diameter >1 cm/y), ischemic complications (visceral malperfusion or limb ischemia), uncontrolled hypertension, and intractable pain.[3,16] Open repair was performed early in this series before the introduction of thoracic endovascular stent grafting (TEVAR). Open repair is currently reserved for patients with cATBAD whose anatomy is not amenable for TEVAR or for patients with a high suspicion for connective tissue disorders such as Marfan or Loeys-Dietz syndrome. The details of our descending aortic repair have been described previously.[17,18] After the induction and maintenance of general anesthesia, patients were positioned in the right lateral decubitus position. Adjuncts such as cerebrospinal fluid drainage and distal aortic perfusion were attempted in all patients who were hemodynamically stable. We used a full or modified thoracoabdominal incision. The extent of the aortic replacement depended on the length of the involved aorta.

### TEVAR Procedure

We performed all procedures under general anesthesia using percutaneous or open femoral access. Ultrasound guidance was used when percutaneous access was attempted to verify access to the true lumen. Cerebrospinal fluid drainage was attempted in all patients who were hemodynamically stable. We use intravascular ultrasound to confirm wire placement in the true lumen. We selected devices with <10% oversizing based on the diameter of the proximal nondissected aorta. The subclavian artery was covered as needed to obtain an adequate (>2 cm) nondissected landing zone proximal to the entry tear. We commonly placed a single 15- to 20-cm-long device. We avoided postdeployment angioplasty. Adequacy of therapy, including true lumen expansion and branch vessel flow after deployment, was assessed with intravascular ultrasound and angiography. In patients with rupture, the descending thoracic aorta was covered from the left subclavian to the celiac axis.

### Follow-Up

Follow-up was performed on all patients after discharge until the end of the study period in June 2014 or death by the use of a combination of direct patient contact, telephone interview, referring physician contact, or the National Death Index. Data were gathered on long-term outcomes, reinterventions, and mortality by reviewing inpatient and outpatient clinic records at our institution and by direct telephone outreach to patients. Follow-up was complete for interventions, if performed at our center, and mortality.
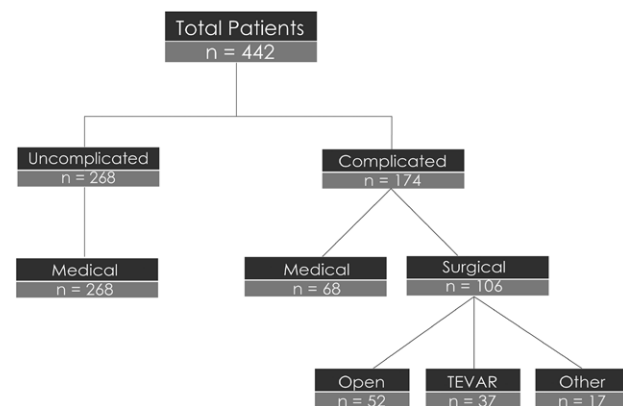


**Figure 1.** Summary flow diagram by patient presentation and treatment. The treatment modalities included medical, open aortic surgical, thoracic endovascular aortic repair (TEVAR), and other peripheral vascular procedures.

## Statistical Methods

For those requiring intervention, new deficits, not present before operation, were considered postoperative outcomes. In-hospital and long-term outcomes were compared by contingency table methods, $t$ tests, and Wilcoxon rank-sum statistics as appropriate for variable distributions. Univariate and stratified analyses presented in Tables 1 and 2 use Cochran-Mantel-Haenszel tests for heterogeneity over the treatment and complication strata and separate Pearson $\chi^2$ tests for heterogeneity among the complicated treatment groups. Univariate and stratified survival statistics were computed by use of Kaplan-Meier analysis. Effect of treatment independent of complicated presentation was assessed with multiple Cox regression. A sensitivity analysis was performed to assess the effects of loss to follow-up on estimates of reintervention. In the sensitivity analysis, all losses to follow-up were considered to be failed. Subjects who did not return to clinic, those whom we could not contact, and subjects for whom we could not otherwise ascertain reintervention status were considered lost to follow-up.

## Results

### Early Outcomes

We treated 442 patients with ATBAD with baseline characteristics summarized in Table 1. Mean patient age was 60.2±14.0 years; 168 of 442 (38%) were female. No significant difference in age was noted in terms of complication status, but male sex was more frequently associated with cATBAD. In all, 268 of 442 (60.6%) had uATBAD and were treated medically, and 174 of 442 (39.4%) had cATBAD. Of the cATBAD patients, 68 of 174 (39.0%) were treated medically, 52 (30.0%) were treated with open aortic surgery, 37 (21.3%) were treated with TEVAR, and 17 (9.7%) were treated with

other open peripheral vascular procedures such as axillobifemoral bypass and femoral-femoral bypass.

The early mortality was 7.6% (34 of 442), and there was a significant difference between the early mortality for uATBAD (2.6%, 7 of 268) compared with cATBAD (16.1%, 28 of 174; $P<0.0001$). Early outcomes across treatment groups are presented in Table 2.

### Readmissions

The percentage of patients requiring readmission after initial treatment was 20.3% (101 of 442). Median time to readmission was 3.5 years in medically managed uncomplicated patients, 1.5 years in medically managed complicated patients, 3.3 years for those receiving open aortic repair, and 1.5 years for subjects receiving TEVAR ($P=0.37$ across all groups). Of these, 42 (46.7%) had multiple subsequent admissions.

Of the 101 patients who had readmissions, 12 (11.8%) presented with acute or chronic type A dissection. Of these, at initial presentation, 7 were uncomplicated medically managed, 1 was complicated medically managed, 2 were managed with open repair, and 2 had TEVAR.

### Reinterventions

Aortic reintervention was required in 15.3% (8 of 52) of the cATBAD-open group and 10.8% (4 of 37) in the cATBAD-TEVAR group. Reasons for reintervention in the open aortic repair group included type A aortic dissection in 1 patient and extension of disease in the remaining 7 patients. Reinterventions in the TEVAR group were due to type A

**Table 1.  Baseline Characteristics**

| Variable | Uncomp, % | C-Med, % | C-Open, % | C-TEVAR, % | C-Peri, % | P Value* |
|---|---|---|---|---|---|---|
| Overall (n=442) | 268 (60.6) | 68 (15.4) | 52 (11.8) | 37 (8.4) | 17 (3.9) | … |
| Age, y† | 61.3±12.9 | 56.9±15.8 | 59.0±15.5 | 61.3±15.3 | 57.9±14.6 | 0.18 |
| Males | 153(57.1) | 51 (75.0) | 30 (57.7) | 25 (67.6) | 15 (88.2) | 0.78 (0.06) |
| Females | 115 (42.9) | 17 (25.0) | 22 (42.3) | 12 (32.4) | 2 (11.8) | 0.78 (0.06) |
| Back pain | 200 (74.6) | 46 (67.7) | 42 (80.8) | 29 (78.4) | 11 (64.7) | 0.36 (0.29) |
| Chest pain | 202 (75.4) | 44 (64.7) | 39 (75.0) | 27 (72.9) | 10 (58.8) | 0.56 (0.47) |
| Abdominal pain | 120 (44.8) | 29 (42.7) | 24 (46.2) | 17 (45.9) | 10 (58.8) | 0.56 (0.69) |
| Paraplegia | 0 (0.0) | 11 (16.2) | 2 (3.9) | 4 (10.8) | 1 (5.9) | 0.34 (0.16) |
| Ruptured | 0 (0.0) | 4 (5.9)‡ | 9 (17.3) | 3 (8.1) | 1 (5.9) | 0.87 (0.18) |
| SOB | 96 (35.8) | 23 (33.8) | 16 (30.8) | 10 (27.0) | 5 (29.4) | 0.47 (0.91) |
| TIA | 0 (0.0) | 3 (4.4) | 1 (1.9) | 1 (2.7) | 0 (0.0) | 0.51 (0.74) |
| Stroke | 0 (0.0) | 5 (7.4) | 1 (1.9) | 0 (0.0) | 0 (0.0) | 0.04 (0.14) |
| eGFR on admittance, mL·min$^{-1}$·1.73 m$^{-2}$† | 87.1±38.9 | 85.1±40.1 | 91.6±56.3 | 81.3±41.0 | 75.4±31.2 | 0.61 |
| SBP on admittance, mm Hg† | 151.5±31.5 | 162.7±40.3 | 152.5±35.7 | 137.9±26.2 | 156.8±46.8 | 0.02 |
| DBP on admittance, mm Hg† | 81.0±19.8 | 85.5±24.7 | 81.3±23.0 | 76.5±17.6 | 84.5±23.3 | 0.36 |

C-Med indicates complicated type B aortic dissection treated medically; C-Open, complicated type B aortic dissection treated with open aortic repair; C-Peri, complicated type B aortic dissection presentation treated with a surgical intervention other than open aortic repair or TEVAR such as axillofemoral bypass or femoral-femoral bypass; C-TEVAR, complicated type B aortic dissection treated with thoracic endovascular aortic repair; DBP, diastolic blood pressure; eGFR, estimated glomerular filtration rate; SBP, systolic blood pressure; SOB, shortness of breath; TIA, transient ischemic attack; and Uncomp, uncomplicated type B aortic dissection.

*For 2*n, contingency tables are values from Cochran-Mantel-Haenszel tests for heterogeneity over the treatment and complication strata. Values in parentheses are Pearson $\chi^2$ probabilities for between-treatment-group comparisons among complicated presentations. For continuous variables, $P$ values are from general linear model ANOVA.

†Reported as mean±SD.

‡ Three of these patients died during their medical stabilization.

**Table 2. Postoperative Outcomes**

| Variable | Uncomp, % | C-Med, % | C-Open, % | C-TEVAR, % | C-Peri, % | P Value* |
|---|---|---|---|---|---|---|
| Overall (n=442) | 268 (60.6) | 68 (15.4) | 52 (11.8) | 37 (8.4) | 17 (3.9) | … |
| Pulmonary | 91 (33.9) | 41 (60.3) | 31 (59.6) | 17 (45.9) | 11 (64.7) | 0.22 (0.44) |
| Gastrointestinal | 100 (37.3) | 42 (61.8) | 19 (36.5) | 17 (45.9) | 10 (58.8) | 0.21 (0.04) |
| ARI | 27 (10.1) | 34 (50.0) | 16 (30.8) | 14 (37.8) | 9 (52.9) | 0.38 (0.13) |
| ARF requiring dialysis | 6 (2.2) | 22 (32.4) | 8 (15.4) | 2 (5.4) | 5 (29.4) | 0.004 (0.01) |
| Recurrent pain | 16 (6.0) | 5 (7.4) | 8 (15.4) | 7 (18.9) | 2 (11.8) | 0.11 (0.33) |
| Stroke | 0 (0.0) | 6 (8.8) | 1 (1.9) | 3 (8.1) | 0 (0.0) | 0.71 (0.26) |
| TIA | 1 (0.4) | 2 (2.9) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0.16 (0.37) |
| Paraplegia | 0 (0.0) | 0 (0.0) | 1 (1.9) | 2 (5.4) | 1 (5.9) | 0.05 (0.24) |
| Encephalopathy | 6 (2.2) | 15 (22.1) | 2 (3.9) | 6 (16.2) | 3 (17.7) | 0.53 (0.05) |
| Sepsis | 6 (2.2) | 15 (22.1) | 6 (11.5) | 1 (2.7) | 2 (11.8) | 0.01 (0.05) |
| LOS, d† | 8 (6–11) | 13.5 (8–22.5) | 21.5 (16.5–33) | 12 (8–20) | 11 (7–21) | <0.0001 |
| Early mortality | 6 (2.2) | 13 (19.1.) | 6 (11.5) | 5 (13.5) | 4 (23.5) | 0.63 (0.54) |

ARF indicates acute renal failure; ARI, acute renal insufficiency; C-Med, complicated type B aortic dissection treated medically; C-Open, complicated type B aortic dissection treated with open aortic repair; C-Peri, complicated type B aortic dissection presentation treated with a surgical intervention other than open aortic repair or TEVAR such as axillofemoral bypass or femoral-femoral bypass; C-TEVAR, complicated type B aortic dissection treated with thoracic endovascular aortic repair; LOS, length of stay; TIA, transient ischemic attack; and Uncomp, uncomplicated type B aortic dissection. Early mortality includes 30-day and in-hospital mortality.

*For 2×n, contingency tables are values from Cochran-Mantel-Haenszel tests for heterogeneity over the treatment and complication strata. Values in parentheses are Pearson $\chi^2$ probabilities for between-treatment-group comparisons among complicated presentations. For continuous variables, P values are from general linear model ANOVA.

†Reported as median (quartiles 1 through 3). P value for LOS was computed by the Kruskal-Wallis procedure.

aortic dissection in 2 patients, type I endoleak in 1 patient, and ruptured descending aorta in 1 patient.

In the uATBAD group, 15.0% (40 of 268) required interventions on later readmission. Reasons for intervention included hemothorax evacuation, open repair resulting from aortic aneurysm formation, and repair of type A aortic dissection.

**Late Follow-Up**

Median follow-up time was 4.6 years (range, 1.9–7.8 years). The longest follow-up available in TEVAR group was 7.5 years. Loss to follow-up for long-term reintervention for the overall cohort was 22%. Sensitivity analysis for long-term reintervention among patients with incomplete follow-up demonstrated a 4.7% increase in possible reinterventions across the board in the most extreme case (all noncontacted patients assumed failed), but with minimal (<3.5% change) to the survival standard error (P=0.50). Intervention-free survival differed significantly between uncomplicated (84.8% and 62.7% at 1 and 5 years, respectively) and complicated (66.6% and 44.3% at 1 and 5 years, respectively) presentations (P<0.0001; Figure 2). Some variation among the treatment groups in the complicated subjects was evident, with TEVAR approaching a lower reintervention-free survival (P≈0.07; Tables 3 and 4).

The overall survival was significantly related to complicated presentation (P<0.0001; Figure 3). Overall survival between treatment groups by complicated status at 1, 5, and 10 years was 91%, 76.6%, and 66.7% among uATBAD-medical; 70.6%, 58%, and 48.5% among cATBAD-medical; 76.9%, 62.7%, and 48.2% among cATBAD-open; and 78.4% and 58.8% among cATBAD-TEVAR, respectively (log-rank P=0.003). The longest follow-up available for

cATBAD-TEVAR group was 7.5 years. Most of the heterogeneity described by the log-rank P value in these stratified survival figures (Figures 2 and 3) arises from the influence of complicated presentation rather than from treatment per se as evidenced by the Cox-regression estimates in Tables 3 and 4.
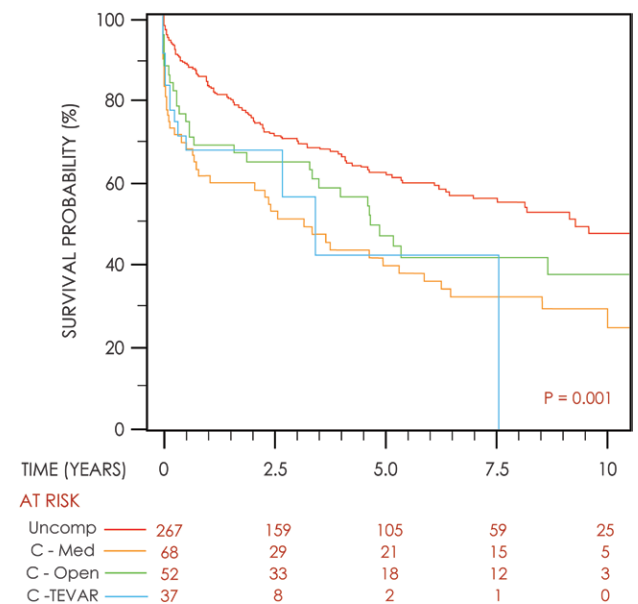


**Figure 2.** Reintervention-free survival by complicated presentation and treatment. C-Med indicates complicated patients treated with medical therapy; C-Open, complicated patients treated with open peripheral vascular procedures; and C-TEVAR, complicated patients treated with thoracic endovascular aortic repair. *The 17 patients in the C-Open group were included in the survival analysis but were removed from this graph for the sake of clarity, given the number of graph lines.
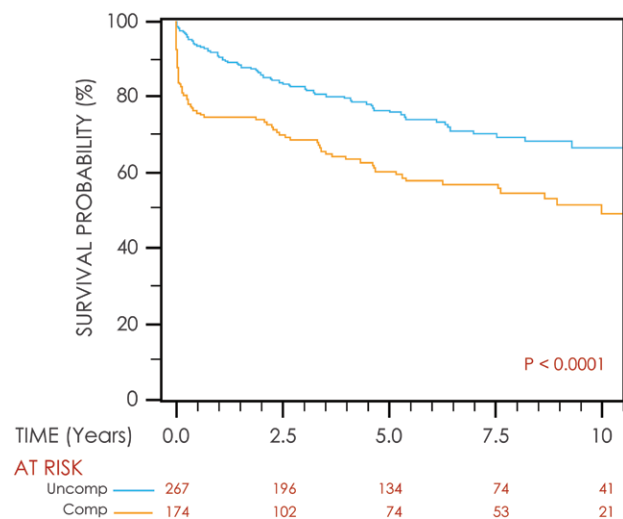
**Figure 3.** Overall survival by complicated presentation.

## Discussion

Similar to the findings in our previous report, this update on ATBAD emphasizes the potential morbidity and mortality associated with ATBAD. The early mortality was dictated by the presence of complications; cATBAD was associated with an early mortality of 16%. Other notable complications were respiratory dysfunction (100 of 174, 57%) and acute renal failure requiring dialysis (55 of 174, 31.6%) in patients presenting with cATBAD. Uncomplicated dissection, however, was associated with acceptable early outcomes with an early mortality of 2.2%.

The results of this study reflect the paradigm shift occurring in the management of ATBAD. The role of TEVAR in the acute setting of cATBAD has been established in previous reports, especially in the setting of organ malperfusion.[6–8,19–23] In this study, the majority of the open aortic repairs for cATBAD were performed before 2010, whereas most of the TEVARs were performed more recently.

Medical management remained the first line of treatment for uATBAD, with long-term survival of 50% to 70% as previously reported.[12,20] In our cohort, all uATBAD patients were treated medically with early mortality of 2.2% but with a need for delayed intervention of 15.3% in late follow-up. Despite favorable outcome in uATBAD compared with cATBAD, as shown in Figure 3, these results demonstrate that there is a need to identify those patients who are at higher risk for future aorta-related complications and mortality.

Few studies have examined the role of TEVAR in the setting of uncomplicated type B aortic dissection. The Investigation of Stent Grafts in Aortic Dissection (INSTEAD) trial[9] was a prospective, randomized trial that included patients in the subacute and chronic phases (2 weeks–1 year) and compared combined TEVAR and optimal medical therapy (OMT+TEVAR) with OMT alone. There was no difference in the 2-year survival between the groups, However, the investigators demonstrated a significantly higher aortic remodeling rate in the TEVAR group.[9] In the 5-year follow-up of the INSTEAD-XL trial,[10] however, there was improved 5-year, aorta-specific survival in the TEVAR group with delayed disease progression

compared to the group receiving OMT alone.[10] A Randomized European Study Comparing Endoluminal Stent Grafting and Best Medical Therapy (BMT) to BMT Alone in the Treatment of Acute Uncomplicated Type B Aortic Dissection (ADSORB) study is the only prospective, randomized, controlled study on uATBAD. It compared OMT with OMT+TEVAR. The published 1-year results show no dissection-related deaths in either group and a significantly higher aortic remodeling rate in the OMT+TEVAR group.[24]

It is noted, however, that in our data the cATBAD-TEVAR subgroup did not have the same follow-up duration as the other groups. In addition, the results of this study on the early mortality of uATBAD of <2.2% must be acknowledged. Although the results of the INSTEAD and ADSORB trials are compelling,[24] further study is needed to better define the criteria to identify patients at risk for late complications.

The variability in presentation of ATBAD and subtlety of symptoms in some cases add to the complexity and difficulty of defining complicated versus uncomplicated dissections. The definition of cATBAD in the literature includes impending rupture, clinical malperfusion, refractory hypertension, hypotension (<90 mm Hg systolic blood pressure), shock, hemorrhagic effusion, total aortic diameter ≥55 mm or increase ≥10 mm, and recurrent symptoms.[25,26]

There is no consensus in the literature on the definition of malperfusion of visceral organs as to whether it should be based on symptoms or laboratory results alone or whether imaging supporting malperfusion is required for the diagnosis. Because the majority of patients receive static computed tomography angiography images alone, radiological diagnosis of malperfusion, especially in cases of dynamic obstruction, can be difficult. In our cohort, 22.6% of all ATBAD patients had acute renal failure, but we considered only the cases requiring dialysis as cATBAD. We had 68 patients who were defined as having cATBAD and were treated medically. Some were too sick to undergo an intervention, but others were not defined as complicated on admission, especially in the earlier years.

The definition of complicated dissection will continue to evolve and expand as imaging techniques improve and we gain the ability to capture the dynamic nature of the dissection flap and its effect on the flow in the true and false lumens

**Table 3.  Independent Effects of Treatment and Complicated Presentation on Overall Survival***

| Parameter | HR | 95% Confidence Limits | *P* Value |
|---|---|---|---|
| Complicated | 2.06 | 1.36 – 3.10 | 0.0006 |
| Peri | 0.86 | 0.38 – 1.94 | 0.7153 |
| Open | 0.83 | 0.49 – 1.41 | 0.4985 |
| TEVAR | 0.94 | 0.47 – 1.87 | 0.8564 |

Complicated indicates complicated presentation; HR, hazard ratio; Open, group of patients treated with open aortic repair; Peri, group of patients who received a surgical intervention other than open aortic repair or thoracic endovascular aortic repair such as axillofemoral bypass or femoral-femoral bypass; and TEVAR, group of patients treated with thoracic endovascular aortic repair.

*Estimates from Cox proportional hazards regression analysis for independent risk factors of long-term survival. HRs are referenced to uncomplicated status and to medical management.

**Table 4.   Independent Effects of Treatment and Complicated Presentation on Reintervention-Free Survival\***

| Parameter | HR | 95% Confidence Limits | P Value |
|---|---|---|---|
| Complicated | 1.22 | 0.88 – 1.67 | 0.2329 |
| Peri | 1.07 | 0.55 – 2.06 | 0.8487 |
| Open | 0.95 | 0.62 – 1.44 | 0.7949 |
| TEVAR | 1.67 | 0.96 – 2.90 | 0.0704 |

Complicated indicates complicated presentation; HR, hazard ratio; Open, group of patients treated with open aortic repair; Peri, group of patients who received a surgical intervention other than open aortic repair or thoracic endovascular aortic repair such as axillofemoral bypass or femoral-femoral bypass; and TEVAR, group of patients treated with thoracic endovascular aortic repair.

\*Estimates from Cox proportional hazards regression analysis for independent risk factors of reintervention-free survival. HRs are referenced to uncomplicated status and to medical management.

and the perfusion of renal and visceral vessels.[24] Computed tomography angiography remains the top choice for imaging ATBAD, and magnetic resonance angiography is the second choice. In general, images acquired with these 2 modalities are static and present an arbitrary point in the cardiac cycle. Therefore, they are unable to capture the dynamic nature of the dissection flap.[27–29] Recent publications acknowledge the importance of dynamic aortic evaluation in the treatment of aortic pathologies, especially aortic dissections.[30–33]

TEVAR is a valuable tool in the treatment of cATBAD, but its role in management of uATBAD is still being defined. Although the early results are promising and the complication rates are low, complications still exist. Comparable to previously reported TEVAR data by other groups,[19,34] our results demonstrate that the early mortality rate for the cATBAD-TEVAR group was 13.5%, the paraplegia rate was 5.9%, the stroke rate was 8.1%, retrograde type A aortic dissection occurred in 8%, and aortic reinterventions were required in 10.8%. Long-term durability of TEVAR remains an unanswered question.

Identifying possible risk factors for future complications would improve the management of patients with ATBAD and help tailor the treatment options for each patient on the basis of their risk stratification for future adverse events. Several studies have suggested some predictors, including initial aortic diameter >4 cm, initial diameter of false lumen >22 mm, size of proximal entry tear >10 mm, diameter of false lumen >22 mm, initial aortic diameter >4 cm, refractory pain, and hypertension.[35–38]

As a retrospective analysis, this study should be viewed with certain limitations and biases. It was performed as an observational study; thus, the results should be limited to hypothesis deriving. Although groups were divided into complicated and uncomplicated and analyzed by treatment modality, late outcomes by intervention should be viewed with some reservation because the follow-up periods were different. In addition, definitions of complicated dissection continue to evolve, and although we attempted to maintain a consistent definition of complicated dissection that took into consideration of clinical, laboratory, and radiographic criteria, we acknowledge that as the indications for TEVAR expanded, more patients may have received endovascular intervention

for "complicated" dissection in the later period compared with earlier in the study period.

## Conclusions

Early outcomes and treatment of ATBAD are still determined by the presence of complications at initial presentation. Medical management is associated with a low early mortality (2%) in patients who present uncomplicated. Patients with cATBAD are still burdened with significant early morbidity and mortality. Despite the increasing use of TEVAR for cATBAD, indications for TEVAR in patients with uATBAD should be considered on a case-to-case basis with consideration of the availability of local expertise, supplies, equipment, and infrastructure. Future studies are required to better define and possibly expand the indications for uATBAD and to determine the risk factors that predict delayed aorta-related complications in the subacute and chronic phases.

## Disclosures

Dr Azizzadeh is a consultant for Gore and Medtronic. Dr Estrera, is a consultant for Gore and has received speaker fees from Maquet. The other authors report no conflicts.

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